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EXECUTIVE SUMMARY

We applied population estimation models to Eastern Bering Sea trawl survey, catch sampling, and commercial catch data for red king crabs in Bristol Bay during 1972-1998, blue king crabs off St. Matthew Island during 1978-1998, and blue king crabs off Pribilof Islands during 1975-1998. A length-based analysis (LBA) was applied to male and female red king crabs and a catch-survey analysis (CSA) was applied to male blue king crabs.

For Bristol Bay red king crabs, an above average year class, likely from spawning in 1989-1991 (hereafter termed the 1990 year class), continued to grow to the larger sizes. The majority of female crabs in this year class reached size at maturity in 1997. More than half of the males in this year class reached size at maturity in 1998, but few have grown to legal size. Compared to 1997, abundance of mature males increased from 11.4 to 17.3 million and legal male abundance increased from 6.9 to 7.5 million. Mature female abundance increased slightly from 28.4 to 28.9 million and effective spawning biomass increased significantly for the second year in a row from 37.2 to 56.3 million pounds. The effective spawning biomass has surpassed the rebuilding level of 55 million pounds thereby triggering an increase in the mature male harvest rate from 10% to 15%. By multiplying the 15% harvest rate times mature male abundance times an average weight of 6.3 pounds per legal crab, an overall preseason guideline harvest level (GHL) of 16.4 million pounds was set for the November 1, 1998 opening.

For St. Matthew blue king crabs, CSA estimates the prerecruit (sublegal mature males) and legal-sized male crabs. Compared to 1997, legal male abundance showed no change at 3.5 million crabs. Prerecruit abundance declined slightly from 2.0 to 1.8 million and accordingly the total mature male abundance declined from 5.4 to 5.3 million. As in the past the estimates of abundance are tempered by wide confidence intervals. Multiplying the mature male abundance by the 20% harvest rate and a mean weight of 3.9 pounds, a GHL of 4.1 million pounds was set for the September 15, 1998 opening.

For Pribilof Islands blue king crabs, legal male abundance declined from 1.1 to 0.9 million, while prerecruit abundance remained the same at 0.2 million. Taken together, mature male abundance declined from 1.3 to 1.1 million crabs. For red king crabs, 700,000 mature males were estimated by the National Marine Fisheries Service (NMFS) using area-swept methods. In recent years, trends in survey and fishery performance data and imprecision in abundance estimates for blue and red king crabs off Pribilof Islands have justified a 10% harvest rate. Applying a 10% harvest rate to the mature male abundance and multiplying by an average weight of 6.35 pounds for blue king crabs and 8.7 pounds for red king crabs yields 700,000 and 600,000 pound GHLs respectively for 1998. An aggregate GHL was set at 1.3 million pounds for a combined fishery to avoid bycatch that would occur if each were held separately. The Pribilof Islands fishery was scheduled to open on September 15, 1998.

INTRODUCTION

The NMFS conducts annual trawl surveys of crab abundance in the eastern Bering Sea. For each crab stock, the Alaska Department of Fish and Game (ADF&G), in consultation with NMFS, sets preseason GHLs with an exploitation rate management strategy applied to estimates of mature male crab abundance. For most commercially exploited stocks in the Bering Sea, abundance is estimated by area-swept methods and reported annually by NMFS (e.g., Stevens et al. 1998).

For a few stocks, ADF&G developed population models to minimize the effects of annual survey measurement errors on current-year abundance estimates by incorporating survey and fishery data from prior years into the estimation process. Abundance estimates from these models are used to manage the crab fisheries and to set annual crab bycatch limits in the groundfish fisheries. Because of the high level of interest in these population estimates by the fishing industry, ADF&G began an annual report series on stock status in 1996 as a public information service (Zheng et al. 1996a).

The goal of this report is to provide concise and timely information on stock status in advance of upcoming Bering Sea king crab fisheries. This provides the industry and public access to the same information used by the agencies to evaluate status of stocks as estimated by population models. In this report we briefly review estimation methods, current stock status, implications for crab fishery management and regulation of crab bycatch in groundfish fisheries, and a brief outlook for the future. Trawl survey data used in this year's analyses were provided by Dr. Brad Stevens and Dr. Bob Otto of NMFS, Kodiak, Alaska.

METHODS

Survey Methods

NMFS has performed annual trawl surveys of the eastern Bering Sea since 1968. Two vessels conduct this multispecies, crab-groundfish survey during summer each equipped with an eastern otter trawl with 83 ft headrope and 112 ft footrope. Stations are sampled in the center of a systematic 20 X 20 nm grid overlaid in an area of ≈140,000 nm^2. The towed area is estimated, and fish and invertebrate catches from each station are sampled, enumerated, measured and weighed. An update of Stevens et al. (1998) will be published to provide details on the 1998 survey results for: Bristol Bay and Pribilof Islands red king crabs, St. Matthew and Pribilof Islands blue king crabs, and eastern Bering Sea Tanner, snow, and hair crabs. Status of Bering Sea groundfish stocks also assessed by this survey will be reported in an update to NPFMC (1997).

Analytical Methods

Overview. The annual trawl survey is an essential data-gathering tool on the status of crab stocks in the eastern Bering Sea. Yet, year-to-year variation in oceanographic conditions lead to changes in species distributions and availability to survey gear. These changes and other measurement errors can lead to unexpected shifts in area-swept abundance estimates unrelated to true changes in population size. Estimates from previous years' surveys and commercial catches provide valuable auxiliary information to help decipher real population changes from survey measurement errors. Population estimation models were developed to incorporate crab size, sex, and shell condition data from annual surveys, commercial catches and catch samples. Model estimates based on multiple years of data and multiple data sources are generally more accurate than area-swept estimates from current-year survey data alone. ADF&G uses these estimates for fishery management of the modeled stocks.

Because the quantity and quality of data vary among crab stocks, no single analytical model is ideally suited for all situations. Therefore, the following approaches were developed for use with eastern Bering Sea king crabs that are tailored to differing levels of information: *length-based analysis (LBA)* for stocks with high-quality size composition data; and *catch-survey analysis (CSA)* for stocks lacking detailed size composition data or where the survey catchability coefficient is unknown (Zheng et al. 1997a; Collie and DeLong 1998). We apply LBA to Bristol Bay red king crabs and CSA to St. Matthew and Pribilof Islands blue king crabs. A brief description of these two methods and their application to king crab stocks in the Eastern Bering Sea follows.

Length-based Analysis. The LBA is an analytical procedure to estimate annual abundance of crab stocks for which extensive high-quality data are available, such as Bristol Bay red king crabs. The LBA makes use of detailed annual data on size, sex, and shell condition from trawl surveys, onboard and dockside catch samples, and annual commercial harvests. Males and females are modeled separately by 5 mm carapace length (CL) intervals as newshell (i.e., those that molted within the past year) and oldshell crabs (i.e., those that have not molted within the past year). The annual abundance of crabs at each length group is a combined result of recruitment, growth, natural mortality, and harvest. Collie and Kruse (1998) estimated the trawl survey catchability coefficient *(q)* to be near unity for red king crabs in Bristol Bay, and $q = 1$ is assumed for area-swept and LBA methods. An overview of the approach is provided in Zheng et al. (1996b).

Catch-survey Analysis. Collie and DeLong (1998) updated the two-stage CSA model (Collie and Kruse 1998) to a three-stage (i.e., three age-size groups) approach. As with the LBA, the CSA estimates survey measurement errors and "true" stock abundance. The CSA model is less complex, is only applied to male crabs, and it requires less detailed size composition data than the LBA. Instead of tracking multiple 5 mm size groups as the LBA does, CSA considers only three age-size groups of crabs: prerecruits, mature crabs

that are one molt away from attaining legal size; recruits, mature newshell crabs that molted to legal size within the past year; and post-recruits, crabs that have been legal for more than one year. The previous two-stage CSA only considered recruit and post-recruit crabs. In the three-stage version mature and legal abundance and associated 95% confidence intervals can be estimated each year. These improvements are important because GHLs for eastern Bering Sea king crabs are based on estimates of both mature and legal crabs. The updated model provides a new series of abundance estimates over the years that the St. Matthew and Pribilof Islands stocks have been surveyed.

CURRENT STOCK STATUS

Bristol Bay Red King Crabs

LBA estimates of Bristol Bay red king crab abundance and 95% bootstrap confidence limits for 1998 are shown in Table 1. Historical changes in legal male and mature female abundance are graphed in Figure 1. Growth of the above average 1990 year class increased abundance of the larger size groups of the surveyed stock. This growth of the recruitment pulse resulted in a substantial increase in the prerecruit male abundance from 10.6 million to 18.1 million crabs in 1998 while legal males realized only a small increase from 6.9 to 7.5 million crabs. As a result, the abundance of mature male crabs increased from 11.4 to 17.3 million. Abundance of mature female crabs in 1998 (28.9 million) was similar to 1997 (28.4 million). Effective spawning biomass[1] (ESB) increased significantly from 37.2 to 56.3 million pounds. ESB is just over the target rebuilding level of 55 million pounds. Later in this report, we discuss associated changes in fishery management with attainment of the rebuilt level and speculate on the future prospects for this stock.

Abundance by size of male and female crabs as estimated by area-swept methods and the LBA are compared annually to cross check the survey data and model estimation procedures. We carefully scrutinized the mature female abundance estimated from the standard survey tow data by both methods. In 1998, additional survey tows were made as part of an auxiliary NMFS study on 15- and 30- minute tow duration. Analysis of data from these tows corroborated the results from standard survey stations and indicated that the significant increase in all size classes of mature female abundance was not an artifact of sampling errors. We concluded that mortality has declined since 1994 and that catchability of large females in the trawl survey gear may possibly have increased this year. Trends in previous years' LBA estimates also indicated that a reduction in mortality likely occurred since 1994. Unfortunately, mortality and catchability are not easily separated and difficult to estimate from survey data alone. The procedure for estimating a change in catchability requires multiple years of data after a change is recognized; therefore, only change in mortality was evaluated. Three shifts in mortality rate over time were built into the LBA previously. We updated the LBA model to estimate a new mortality shift during 1994 to 1998 given the apparent reduction in mortality since 1994. In

[1] ***Effective spawning biomass*** is the estimated biomass of mature female crabs that the population of mature male crabs successfully mate in a given year.

previous year's assessments, the mortality rate was assumed the same from 1985 to 1997. Lower mortality allows more crabs to survive to larger sizes. Therefore, compared to previously published estimates, current estimates of mature and legal male crab abundance increased during 1994 to 1997 and mature female crabs increased during 1995 to 1997 owing to the change in estimated mortality and addition of 1998 data.

Area-swept and updated LBA estimates of abundance by size for the past five years are shown in Figure 2. For male crabs the LBA estimates are similar to or slightly greater than area swept estimates over most sizes from 1994 to 1996 but smaller in 1997. Abundances of small male crabs (<115 mm CL) and legal crabs appear to be overestimated by the area-swept method in 1997. We reported on this in last year's assessment report (Zheng et al. 1997) and Dr. Robert Otto of NMFS, based on his analysis, reported a similar opinion at the annual meeting with industry in Ballard, Washington, in October 1997. The survey results in 1998 bear this out. For female crabs, the LBA estimates are greater than area swept estimates over most sizes from 1994 to 1997 but much smaller in 1998. This is caused by high survey abundance of large mature females (>115 mm) in 1998 that cannot be explained by low abundance in 1994 -1997. The LBA is intended to address such year-to-year inconsistencies in the survey results.

Insights into changes in annual survey results can be gained by examining the size frequency distributions over the past five years (Figure 3). Area-swept estimates suggest a substantial decrease in abundance of males between 95 mm and 110 mm CL and males > 155 mm CL from 1997 to 1998. The dominant mode of males at 95 to 110 mm CL in 1997 grew in size to 110 to 130 mm CL in 1998 as expected but abundance unexpectedly declined sharply despite lower mortality. Also for large males, the abundance estimates for 1998 are much more consistent with results for 1994-1996 than with 1997. For females the survey in 1998, not 1997, produced some unexpected results. The large increase in abundance of mature females in 1998 was not fully anticipated based on growth alone of the 1990 year class. The dominate mode of females shifted from 97.5 mm CL to 107.5 mm CL as crabs molted to larger sizes but abundance of large females (>119 mm CL) increased an average of 70% in 1998 from female abundance (>114mm CL) in 1997. Lower mortality doesn't fully account for these increases so the LBA estimate of mature females is still about 15% below the area-swept estimate (Figure 1). However, LBA and area-swept estimates both indicate the ESB exceeds 55 million pounds. An increase in catchability of the trawl survey gear can affect area-swept abundance estimates and future survey data should provide sufficient information to evaluate this hypothesis.

Abundance estimates of juvenile males <95 mm CL and females <90 mm CL are unreliable and are not included in the LBA. However, size frequency modes of juvenile crabs tracked the strong year class that is apparently now fully recruited to the modeled stock (Figure 3). In 1998, abundance of crabs from the 1991 year class recruiting into the modeled population were at low levels similar to the recruitment experienced in the previous decade (Table 1).

The 1998 size frequency distribution shows a new year class of crabs centered about 70 to 75 mm CL. Unlike the 1990 year class, this new mode was not observed as it passed through the 50 to 65 mm CL size interval in 1996 and 1997. Therefore, the significance of this mode of small crabs is not yet clear. Repeated observations over the next few years will allow estimation of the size of the size of this year class.

Just as historical survey results enter into the LBA and modify the interpretation of data from 1998, the 1998 survey results also provide additional information about reconstructed stock size in recent years. This is a common feature of contemporary estimation procedures for fish and invertebrate populations. Thus, historical abundance estimates generated with data from 1972-1998 (Table 1) differ somewhat from estimates generated with data from 1972-1997 (see Table 1 in Zheng et al. 1997b). Estimates for recent years change the most; older estimates remain most stable. Likewise, next year's assessment will bring new data to bear on the status of the stock.

Blue King Crabs

St. Matthew Island. CSA estimates of St. Matthew Island blue king crab abundance and 95% bootstrap confidence limits for 1998 are shown in Table 2. Compared to 1997, all segments of the population showed slight decline in abundance except postrecruits (old-shell legals). Prerecruit abundance (105-119 mm CL) declined to 1.8 million crabs from 2.0 million in 1997 and accounts for most of the decline in mature abundance (≥105 mm CL) to 5.3 million crabs in 1998. Abundance of legal males remained at 3.5 million crabs as a decline in recruits was compensated by an increase in postrecruits (Figure 4.)

Pribilof Islands. For the Pribilof Islands, changes from last year included continued decline in mature male abundance from 1.3 to 1.1 million crabs and a decrease in legal male abundance from 1.1 to 0.9 million crabs (Table 2, Figure 4). This change is attributable to a decrease in newshell recruits (135-148 mm CL). A sharp decline of recruits to the fishery was partly offset by a small increase in postrecruits. Prerecruit abundance was unchanged from 1997 to 1998 at 0.2 million crabs.

FISHERY MANAGEMENT IMPLICATIONS

Bristol Bay Red King Crabs

Potential Effects of Recent Management Actions. Decline in bycatch of red king crabs in directed crab fisheries and in groundfish fisheries probably contributed to the apparent decline in mortality since 1994. In 1996, more stringent bycatch measures were implemented in the groundfish fisheries. Not only were bycatch caps reduced but non-pelagic trawling was prohibited in the Red King Crab Savings Area and all trawling was prohibited in the Nearshore Bristol Bay Closure Area (Witherell and Roberts 1996). Also,

an industry sponsored bycatch avoidance program has likely lowered bycatch of prohibited species.

Regarding directed crab fisheries, the Bristol Bay red king crab fishery was closed in 1994 and 1995 and a new harvest strategy was adopted in 1996 to conserve and rebuild the stock. Management measures aimed to decrease bycatch of red king crabs in other directed crab fisheries include: area closures in the (Tanner crab) fishery; coincident openings of the red king and Tanner crab fisheries to minimize bycatch; and gear restrictions to reduce bycatch of female and sublegal male crabs. The closure of the Bristol Bay red king crab fishery in 1994 and 1995 and the Tanner crab fishery in 1997 and 1998 also reduced bycatch of red king crabs.

Typically as abundance increases, the geographic area inhabited by a crab stock expands. Comparison of the crab abundance by survey station in 1994 to that in 1998 shows similar geographic distributions but greater abundance overall (Figure 5). Abundance appeared to increase most significantly in the two trawl closure areas, however it is premature to infer cause and effect at this time. Geographic distribution is affected by population size structure and associated preferred depth ranges and habitats. We suspect that a combination of conservation measures plus a good 1990 year class have combined to improve the status of this stock.

Directed Crab Fishery. The Alaska Board of Fisheries harvest strategy for Bristol Bay red king crabs sets a GHL by harvest rate coupled to a fishery threshold (ADF&G 1998). When the stock is at or below threshold of 8.4 million mature females (≥90 mm CL) or 14.5 million pounds of ESB, the fishery is closed. When the stock is above both of these criteria, GHL is determined by the ESB and abundance of mature and legal-sized males. A mature male harvest rate of 10% is applied to promote stock rebuilding when ESB is below the target rebuilding level of 55 million pounds. Once the stock is rebuilt (at or above 55 million pounds of ESB) a 15% harvest rate is applied to mature male abundance. To prevent a disproportionate harvest of large male crabs, the GHL is capped so that no more than 50% of the legal male crabs may be harvested in any one year.

In 1998 the estimates of mature female abundance and ESB were 28.9 million and 56.3 million pounds, respectively – both above the thresholds needed to conduct a directed commercial fishery. Because ESB exceeds the target rebuilding level of 55 million pounds, a 15% harvest rate is applied. Applying this harvest rate times mature male abundance of 17.3 million results in a harvest of 2.58 million crabs. Because 1.05 million is only 35% of the legals, the 50% cap is not required. By multiplying 2.58 million crabs times an average weight of 6.3 pounds per legal crab, a preseason GHL of 16.4 million pounds has been established for the 1998 fishery. A total of 3.5% of the GHL or 600,000 pounds is reserved for the community development quota (CDQ) fishery resulting in a commercial fishery GHL of 15.8 million pounds. The actual CDQ harvest level will be based on the total catch from the commercial fishery.

Implications on the Bering Sea Groundfish Trawl Fisheries. Prohibited species catch (PSC) limits for red king crabs caught during groundfish trawl fisheries are set annually as a function of estimated ESB of Bristol Bay red king crabs (see Figure 3 in Zheng et al. 1996a). When ESB exceeds 14.5 million pounds but is less than 55 million pounds, the PSC is 100,000 crabs. When ESB exceeds 55 million pounds, the PSC is 200,000 crabs. Given the estimate of 56.3 million pounds of ESB for 1998, the red king crab PSC limit for the Bering Sea will be set at 200,000 crabs for 1999 groundfish trawl fisheries.

A portion of the year-round closure to non-pelagic trawling in the Red King Crab Savings Area (162° to 164° W, 56° to 57° N) is open to the rock sole fishery in years when there is a red king crab fishery in Bristol Bay (Witherell and Roberts 1996). Thus, the portion of the Red King Crab Savings Area bounded by 56° to 56° 10' N latitude will remain open to the rock sole fishery in 1999. A separate bycatch limit is established for this area not to exceed 35% of the red king crab prohibited species catch (PSC) limits apportioned to the rock sole fishery by the North Pacific Fishery Management Council.

Blue King Crabs

For St. Matthew Island, the fishery management plan specifies a 20% harvest rate when the stock is above the threshold of 0.6 million mature males (Pengilly and Schmidt 1995). The mature male abundance was estimated at 5.3 million crabs in 1998, well above threshold. A GHL of 5 million pounds based on mature male abundance, the 20% harvest rate, and a mean weight of 3.96 pounds per legal crab. The blue king crab fishery at St. Matthew Island is scheduled to open on September 15, 1998.

For the Pribilof Islands, the fishery management plan specifies a threshold of 0.77 million mature male blue king crabs; no threshold is specified for red king crabs (Pengilly and Schmidt 1995). In recent years, trends in survey and fishery performance data have been used to set an aggregate GHL for a combined blue and red king crab fishery to avoid bycatch problems that would occur if each fishery with separate fisheries. From 1997 to 1998, the abundance of mature male blue king crabs declined from 1.27 to 1.07 million but is above the fishery threshold. NMFS area-swept abundance estimates of mature male red king crabs declined from 1.28 in 1997 to 0.73 in 1998. Given declining abundance, low precision of abundance estimates, and past fisheries' performance below expectations, a 10% harvest rate was used to set the 1998 GHL. A combined GHL of 1.3 million pounds was set for the blue and red king crab fisheries at the Pribilof Islands scheduled to open on September 15, 1998.

FUTURE OUTLOOK

The future outlook for eastern Bering Sea red and blue king crab stocks is mixed. Significant numbers of prerecruit males from the 1990 year class have yet to attain legal size. They will likely sustain harvest of Bristol Bay red king crab in the near future.

However, the harvest rate may fall back to 10% in 1999 if mortality of mature females exceeds growth and recruitment. Several years of reduced abundance appears to follow the 1990 year class as evidenced by low numbers of recruit male and female crabs. Beyond that, the mode of small crabs around 72.5 mm CL may perhaps signal the leading edge of another sizeable year class but it is too soon to be certain. For St. Matthew and Pribilof Islands, wide confidence intervals in the mature male abundance estimates and poor information on juveniles and females make predictions difficult. Based on trends in prerecruits and recruits for blue and red king crabs at the Pribilof Islands, the stocks are not expected to improve in the near term. Trends in abundance of St. Matthew Island blue king crabs imply that this stock may remain fairly stable. Preliminary size frequency data from NMFS suggests a strong mode of male and female blue king crabs around 70-75 mm CL. The three-stage CSA should improve estimates of prerecruit and mature abundance of blue king crab as these small crabs enter the modeled population. Accurate predictions of recruitment beyond 1999 are difficult because juvenile abundance estimates are imprecise and sometimes misleading due to uncertain catchability of small crabs by the survey trawl gear and limited trawlable areas around St. Matthew Island.

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Table 1. Annual abundance estimates (millions of crabs), effective spawning biomass (millions of pounds), and 95% confidence intervals for 1998 for red king crabs in Bristol Bay estimated by length-based analysis from 1972-1998. Size measurements are mm CL.

	Males					Females		
Year	Recruits	Small	Prerec.	Mature	Legal	Recruits	Mature	ESB
mm→	(to model)	(95-109)	(110-134)	(>119)	(>134)	(to model)	(>89)	
1972	NA	13.433	14.956	18.391	9.938	NA	59.756	55.117
1973	29.164	20.371	25.763	22.327	10.767	33.116	70.012	62.961
1974	20.442	14.931	34.477	33.745	14.714	28.195	71.462	92.826
1975	31.867	22.164	35.770	40.744	20.419	21.802	66.003	116.480
1976	42.739	29.906	45.117	48.522	25.290	34.273	75.124	128.924
1977	49.014	34.579	58.426	61.205	30.155	72.307	118.742	162.987
1978	18.973	14.851	57.005	73.848	39.192	46.451	119.728	199.635
1979	12.359	9.120	36.162	72.209	46.583	18.798	92.856	166.637
1980	23.534	16.245	25.528	58.611	43.528	35.859	93.407	165.973
1981	17.391	12.596	17.097	18.056	9.445	13.484	71.264	58.398
1982	23.109	16.176	16.043	10.014	2.938	17.276	29.922	23.609
1983	13.250	9.833	13.766	8.877	2.443	4.771	10.060	16.802
1984	18.832	13.155	12.990	8.096	2.351	12.124	13.904	16.365
1985	8.572	6.529	10.432	6.814	1.799	5.201	7.651	11.421
1986	5.838	4.409	12.083	11.384	4.257	4.110	9.505	15.080
1987	6.064	4.387	10.685	13.171	6.420	9.632	16.351	25.673
1988	5.736	4.173	9.729	13.785	7.861	5.816	17.356	28.947
1989	4.644	3.427	8.927	14.823	9.315	5.586	17.869	31.093
1990	1.367	1.182	6.881	14.522	9.858	0.897	13.545	26.101
1991	4.042	2.781	4.978	11.710	8.419	3.671	13.283	25.679
1992	5.601	3.959	5.994	9.902	6.773	3.231	12.637	24.679
1993	2.290	2.076	6.976	10.157	6.089	1.977	10.927	22.113
1994	1.094	1.012	5.667	8.958	5.015	0.401	8.147	17.812
1995	2.879	2.061	4.741	9.421	6.187	1.492	9.250	20.516
1996	3.023	2.312	5.085	9.919	6.856	3.832	12.631	26.486
1997	19.474	13.165	10.630	11.381	6.850	16.378	28.375	37.171
1998	4.285	3.980	18.128	17.314	7.454	2.047	28.920	56.323
Lower	3.106	NA	14.419	12.721	4.702	1.516	21.832	NA
Upper	6.694	NA	22.109	21.328	9.860	4.107	37.678	NA

Table 2. Annual abundance estimates (millions of crabs) and 95% confidence intervals for1998 for male blue king crabs off St. Matthew and Pribilof Islands by 3-stage catch-survey analysis from 1975 to 1998. Survey catchability is fixed at 1.0 for legals. Estimates of prerecruits are in relative abundance comparable to "area-swept" estimates. St. Matthew Island recruits are newshell males of size 120-133 mm CL and Pribilof Island recruits are newshell males of size 135-148 mm CL. All other legal males are postrecruits. Mature crabs include prerecruits plus legals. Size measurements are mm CL.

	St. Matthew Island					Pribilof Islands				
Year	Prerec.	Mature	Recruit newshell	Post. oldshell	Legal	Prerec.	Mature	Recruit newshell	Post. oldshell	Legal
mm→	(105-119)	(≥105)	(120-133)	(≥120)	(≥120)	(120-134)	(≥120)	(135-148)	(≥135)	(≥135)
1975	NA	NA	NA	NA	NA	4.030	11.247	3.379	3.838	7.217
1976	NA	NA	NA	NA	NA	1.796	9.643	2.769	5.078	7.847
1977	NA	NA	NA	NA	NA	1.785	8.137	1.234	5.118	6.352
1978	1.789	2.945	0.722	0.434	1.156	3.033	8.313	1.227	4.053	5.280
1979	1.877	3.908	1.514	0.517	2.031	1.649	6.994	2.084	3.261	5.345
1980	2.108	5.134	1.589	1.438	3.026	1.088	5.514	1.133	3.294	4.426
1981	2.374	6.334	1.784	2.177	3.960	0.710	3.531	0.748	2.073	2.821
1982	1.758	5.874	2.009	2.107	4.116	0.352	1.964	0.488	1.124	1.612
1983	1.066	4.108	1.487	1.555	3.042	0.395	1.369	0.242	0.732	0.974
1984	0.479	2.133	0.902	0.753	1.654	0.223	0.998	0.272	0.504	0.775
1985	0.316	1.294	0.405	0.573	0.978	0.155	0.849	0.153	0.541	0.694
1986	0.598	1.209	0.268	0.343	0.611	0.042	0.600	0.106	0.451	0.558
1987	0.831	1.614	0.506	0.277	0.783	0.058	0.469	0.029	0.382	0.411
1988	0.999	2.094	0.703	0.391	1.095	0.012	0.279	0.040	0.227	0.267
1989	1.184	2.596	0.845	0.567	1.412	0.360	0.565	0.008	0.197	0.205
1990	1.356	3.197	1.002	0.839	1.841	0.810	1.208	0.247	0.151	0.398
1991	1.652	3.841	1.147	1.041	2.189	0.658	1.509	0.557	0.294	0.851
1992	1.493	3.923	1.398	1.033	2.430	0.611	1.690	0.452	0.628	1.079
1993	1.545	4.161	1.263	1.353	2.616	0.460	1.676	0.420	0.796	1.216
1994	1.316	4.041	1.307	1.418	2.725	0.402	1.616	0.316	0.897	1.214
1995	1.851	4.310	1.113	1.346	2.459	0.410	1.582	0.276	0.895	1.172
1996	2.254	5.096	1.567	1.275	2.842	0.620	1.631	0.281	0.729	1.011
1997	1.957	5.423	1.908	1.558	3.466	0.194	1.269	0.426	0.649	1.075
1998	1.843	5.296	1.656	1.797	3.453	0.192	1.066	0.134	0.740	0.874
Lower	NA	3.73	NA	NA	2.39	NA	0.73	NA	NA	0.55
Upper	NA	6.93	NA	NA	4.53	NA	1.37	NA	NA	1.17

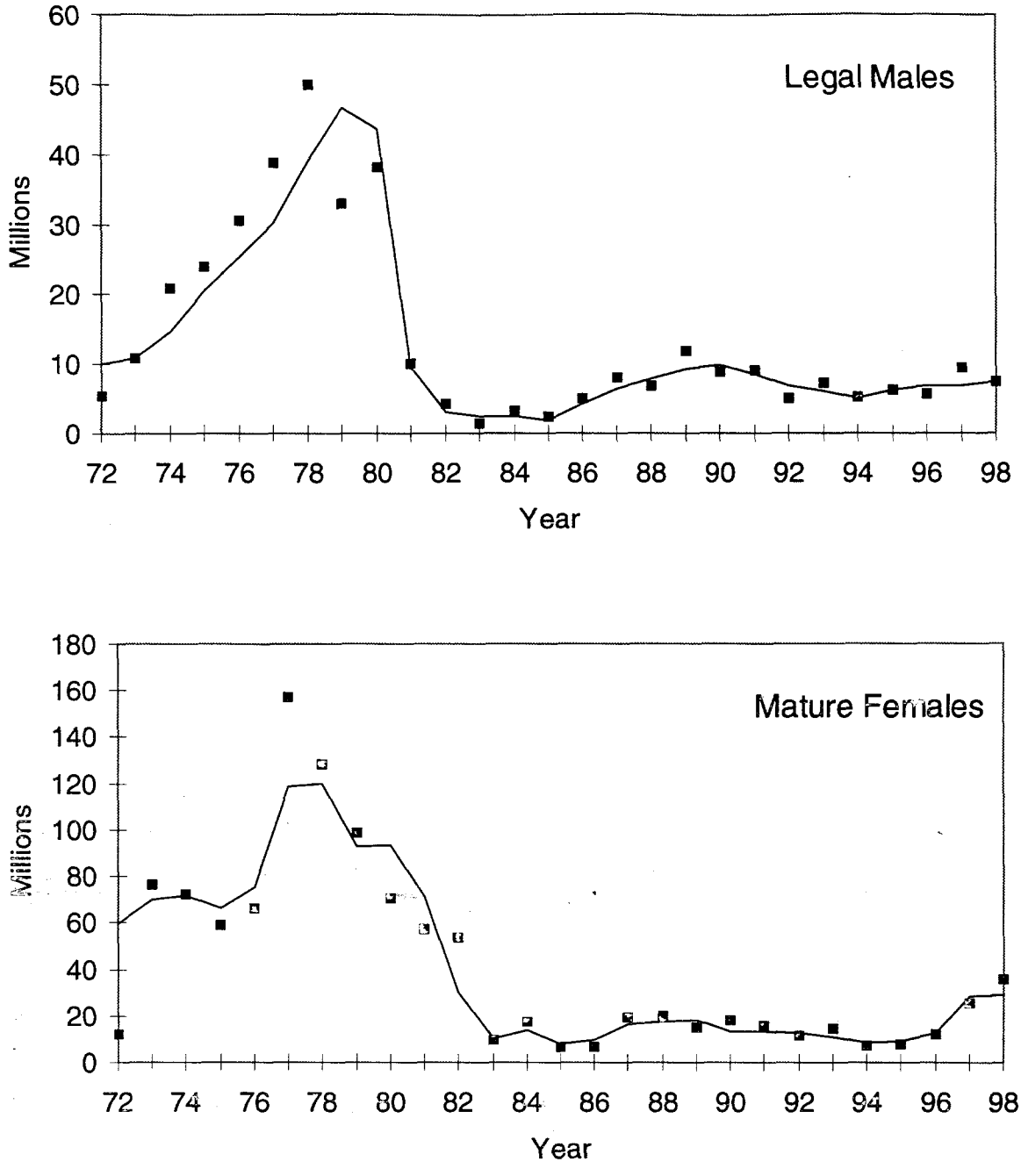


Figure 1. Comparison of abundance estimates (millions of crabs) of Bristol Bay red king crabs from area-swept estimates (dots) and length-based analysis (line) for legal males (top panel) and mature females (bottom panel).

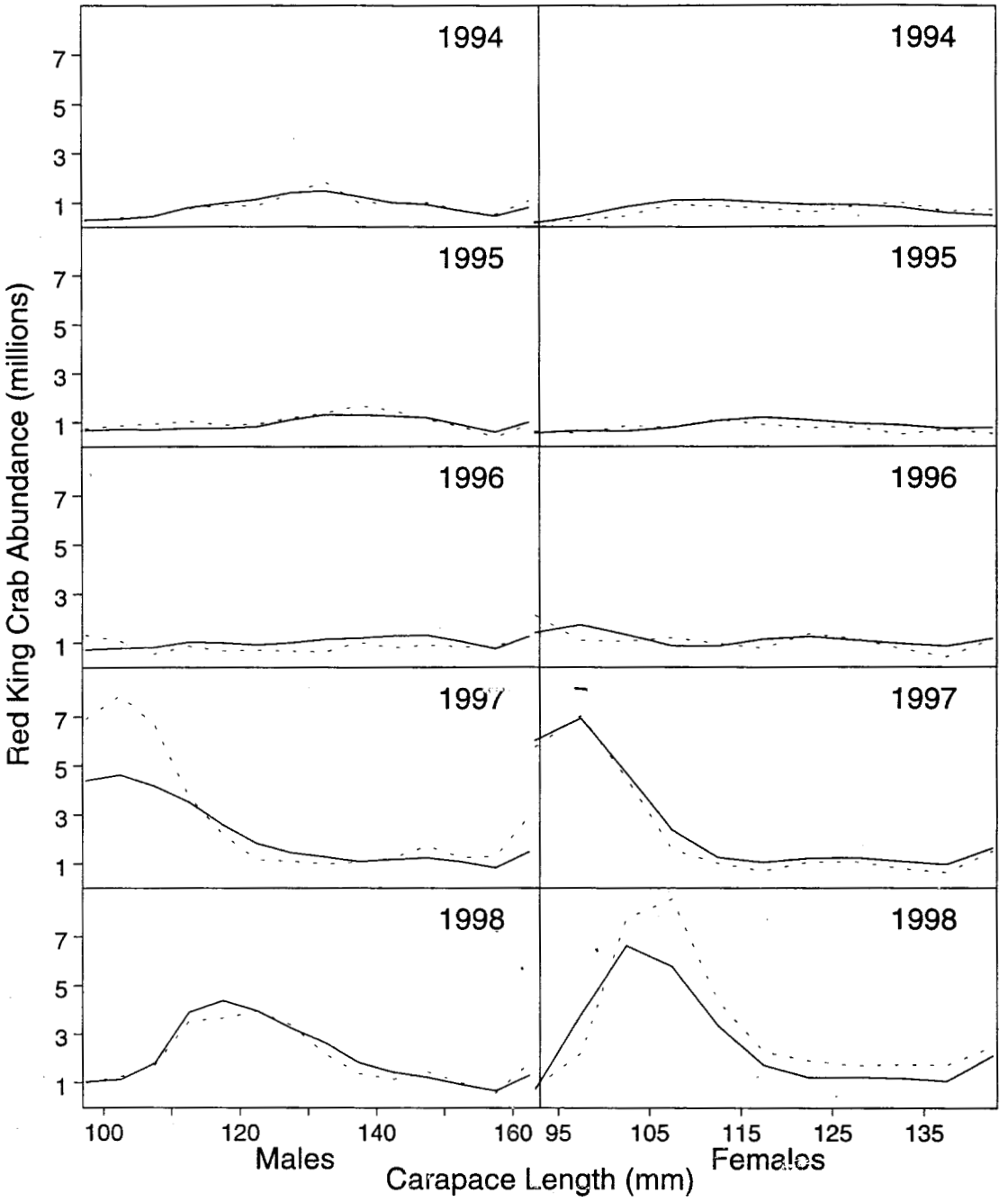
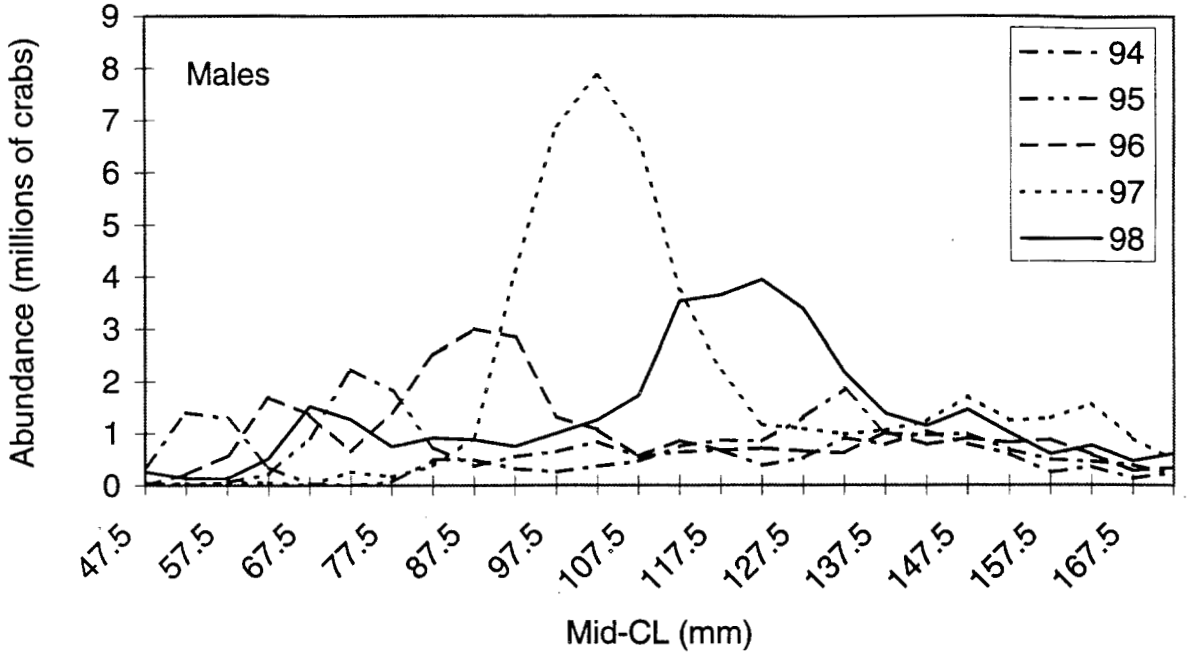


Figure 2. Size-frequency distributions of male and female red king crabs in Bristol Bay, 1994-1998, estimated by area-swept methods (dotted line) and the LBA (solid line).



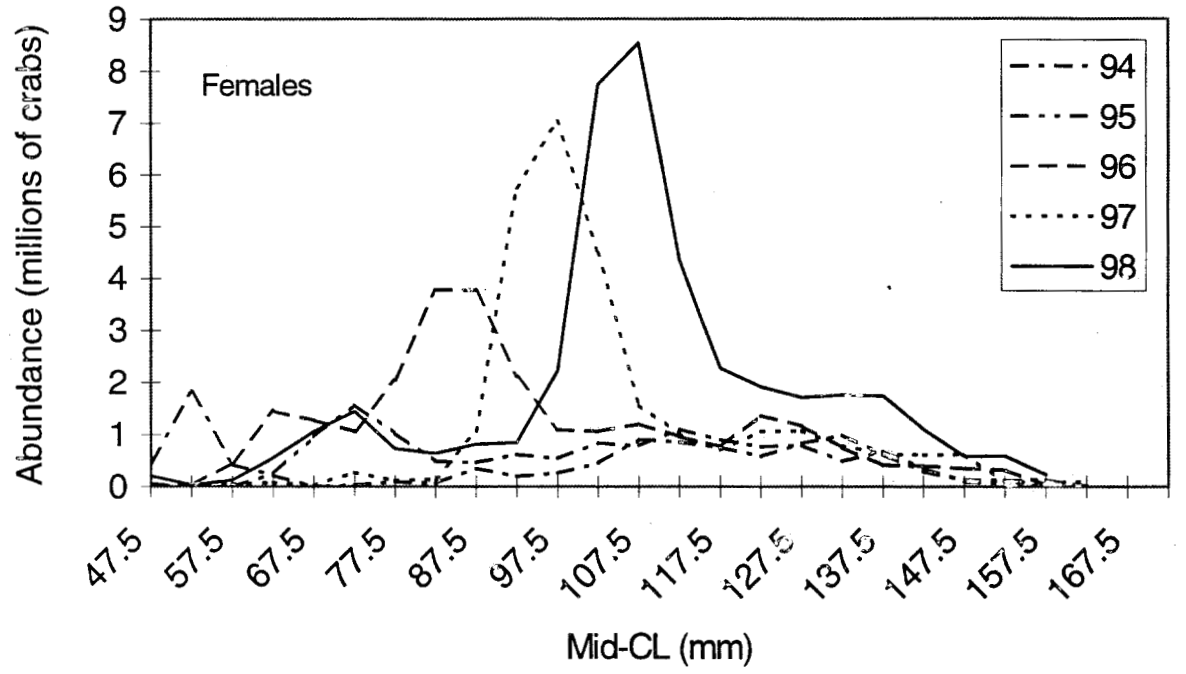
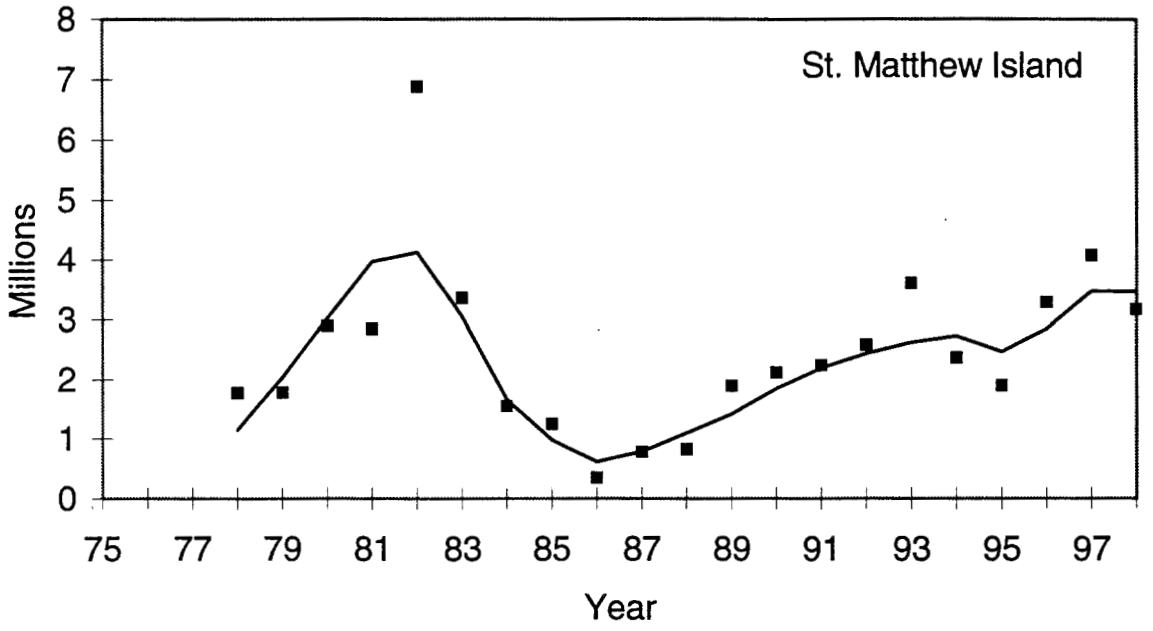


Figure 3. Size frequency distributions of male (top panel) and female (bottom panel) red king crabs in Bristol Bay from NMFS trawl surveys during 1994-1998. Abundance estimates are based on area-swept methods not LBA.



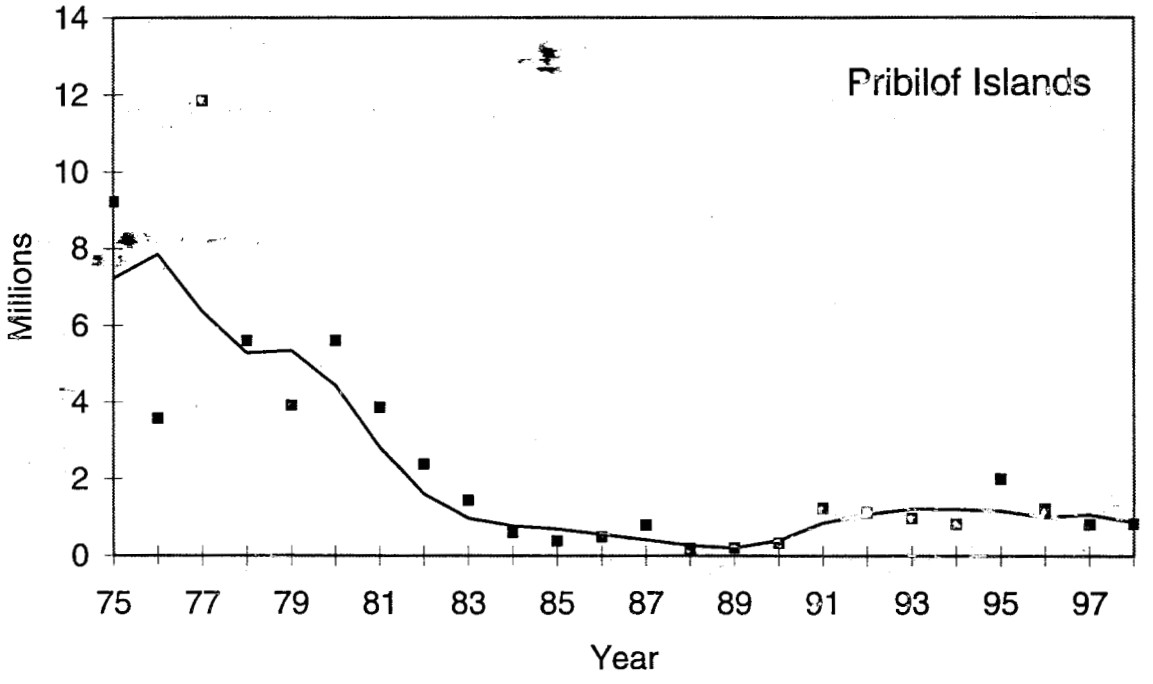


Figure 4. Comparison of abundance estimates (millions of crabs) of legal-sized male blue king crabs from area-swept estimates (dots) and catch-survey analysis (line) for St. Matthew (top panel) and Pribilof Islands stocks (bottom panel).

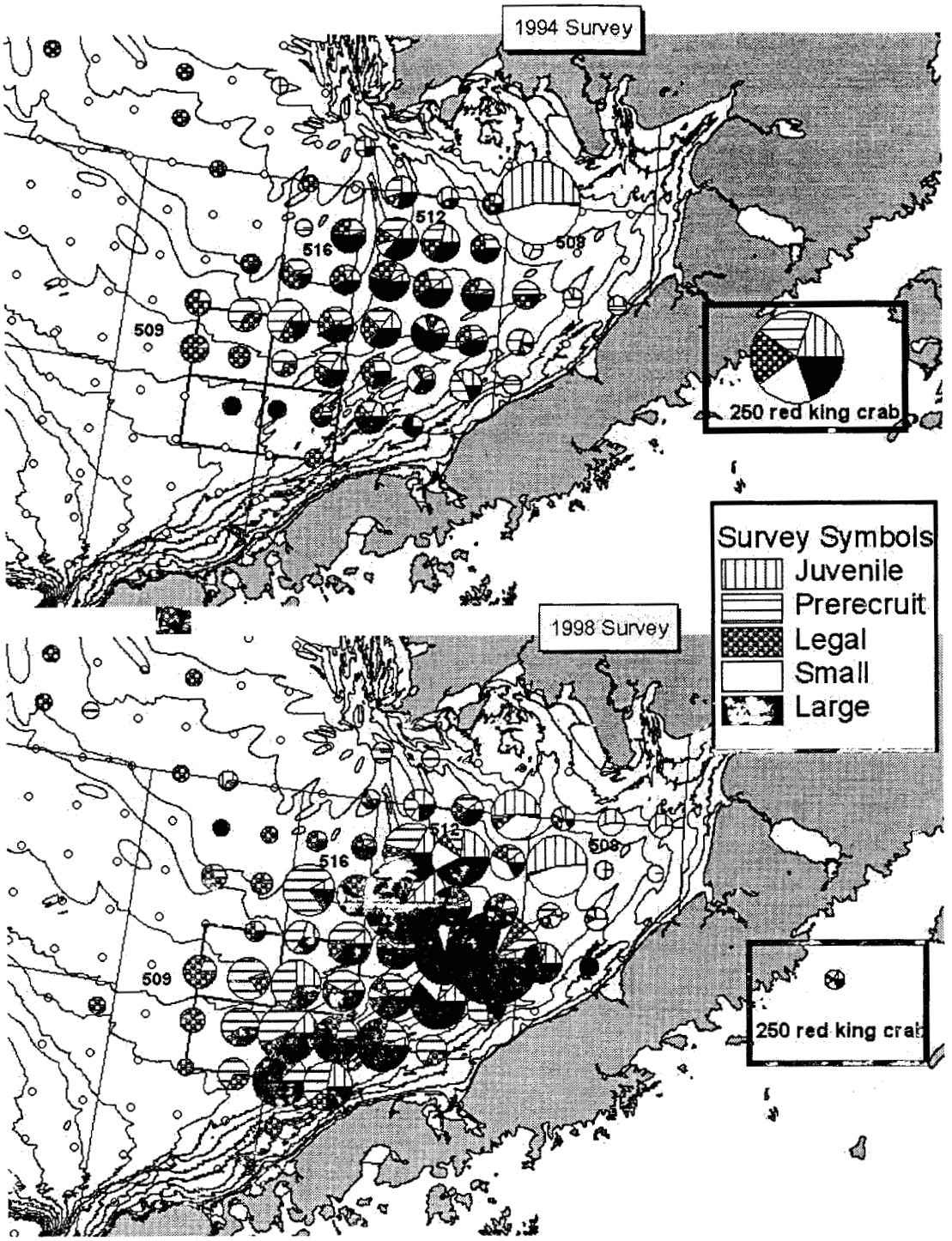


Figure 5. Abundance of male and female red king crabs by station towed during the NMFS annual trawl survey in 1994 and 1998. Abundance is estimated by NMFS area-swept methods and scaled separately for 1994 and 1998. Data were provided by Brad Stevens and Bob Otto, NMFS, Kodiak.